Arthroscopic Remplissage with Bankart Repair for the Treatment of Glenohumeral Instability with Hill-Sachs Lesion

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The following investigation seeks to determine whether arthroscopic Remplissage with Bankart repair is an effective treatment strategy for patients with Bankart lesions and large Hill Sachs defects. Twenty patients underwent arthroscopic Bankart repair with Remplissage for the treatment of recurrent anterior glenohumeral instability and large Hill Sachs defects. Preoperative imaging in all patients identified avulsion of the anterior inferior glenohumeral ligament with an associated Hill Sachs defect that involved greater than 25% of the humeral head. Patients were followed post-operatively with the Western Ontario Shoulder Instability Score (WOSI), the American Shoulder and Elbow Society Score, and the PENN Shoulder Score. Recurrent subluxation or dislocation was documented. Of 20 patients, 15 were male and 5 were female. The average age of the patients was 26.7 years. The average length of follow-up in this series was 24.6 months (range 18.2 to 32.7 months). At final follow-up, three patients reported recurrence of instability, all of which were spontaneously reduced. The average ASES score was 92.5, the average PENN score was 90.0, and the average total WOSI score was 72.74%. Arthroscopic Remplissage with Bankart repair is successful at restoring stability in the majority of patients with recurrent glenohumeral instability with large Hill Sachs lesions. In this patient population, an all arthroscopic technique was able to restore function, diminish pain, and satisfy almost all patients in our series at early to intermediate term follow-up.

Recurrent shoulder instability is a common orthopedic problem affecting approximately 2% of the population[1].With the benefits of a minimally invasive technique (subscapularis preservation, smaller incisions, larger field of view and ability to visualize the posterior capsule), arthroscopic surgery to address anterior shoulder instability has gained popularity amongst orthopedic surgeons over the years. Despite this trend, the inability to address large or "significant" bony glenohumeral defects continues to be a major shortcoming of an all arthroscopic technique.[2-7] Glenoid bone loss and/or humeral head defects are found between 5-70% of patients with recurrent glenohumeral instability[8].The humeral head defects or 'Hill-Sachs' lesions were first described in 1890 by Broca & Hartmann and further classified by Hill and Sachs in 1940[9]. Rowe and colleagues with subsequent work by Burkhart specified the pathologic nature of the Hill-Sachs lesion as large and engaging humeral head defects on the anterior glenoid that often contribute to shoulder instability[7,10]. Since then, humeral head defects have been shown to contribute to anterior shoulder instability in 40%-70% of patients with a first time dislocation, and 80%-93% of patients with recurrent dislocation[11]. In addition, Burkhart has shown that a primary reason for failure of arthroscopic Bankart repair is due to the lack of recognition and treatment of significant bone defects[12].

The increased recognition of the Hill-Sachs lesion and glenoid loss in recurrent instability cases highlight the need for further efforts to fully address bone deficiencies in addition to arthroscopic capsulolabaral repair with suture anchors. Some procedures directly address the humeral head while others manipulate the articular arc length to prevent early engagement. The popular surgical options include the Laterjet-Bristow procedure, humeral head osteotomy, osteochondral allograft transplantation, the 'Connolly' procedure, in which the infraspinatus tendon along with a piece of greater tuberosity is used to address the humeral head defect[8, 13-16], and iliac crest bone graft to the anterior glenoid rim[11]. Each procedure is performed with an open technique and can be accompanied by numerous complications including hardware malfunction, subscapularis insufficiency and glenohumeral osteoarthritis[6, 13]. In most cases of large engaging Hill-Sachs lesions, arthroscopic techniques are still considered inadequate for addressing shoulder instability[3, 6, 7].

In the current study, we evaluated an arthroscopic procedure to address recurrent anterior glenohumeral instability in the setting of significant Hill Sachs defects.The Remplissage technique was first described by Wolf and is named for the French word "to fill"[17]. With this technique, an arthroscopic infraspinatus tenodesis is performed to fill the humeral head defect with concomitant Bankart repair to address capsulolabral insufficiency.This study is the first to report functional outcome measures and recurrence rates for a cohort undergoing the Remplissage technique[17-19].The results of the current study would validate the Remplissage technique as an acceptable alternative to open techniques in addressing recurrent shoulder instability in the setting of large humeral head defects.

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Methods

After institutional review board approval was obtained, we retrospectively identified 20 patients with recurrent anterior shoulder instability who underwent the Remplissage procedure with capsulolabral repair from January 2007 to December 2008. All surgeries were performed by the senior author (JDK). Patients were included in this study if they demonstrated recurrent anterior glenohumeral instability, had failed conservative measures, and had intraoperative findings that demonstrated both a Bankart lesion and a significant Hill Sachs defect.This patient population represents approximately 65% of the patients undergoing arthroscopic surgery for recurrent glenohumeral dislocation during this study period. This was the author's preferred technique for addressing Hill Sachs defects during this time period and significant lesions were defined as defects greater than 25% of the humeral head circumference or engaging the glenoid in the abducted externally rotated position. All patients in this series had a positive apprehension sign or pain in the abducted, externally rotated arm. The patients were enrolled into the study during the post-operative period. The majority of patients in this series had some minor glenoid bone loss, with no patient having significant glenoid defects as part of their pathology. Patients were routinely followed post-operatively at 2 weeks, 4 weeks, 3 months, 6 months, 12 months, and 24 months. At each visit, patients were asked about their symptoms and response to therapy; the final data tabulation was conducted at the latest follow-up by an independent researcher. Patients were assessed utilizing the WOSI scale, ASES score, and PENN shoulder scores. In addition, patients were asked for recurrence of instability in the affected shoulder. All data was collected through a combination of telephone interviews and chart review of the follow up visits.

The surgical outcome was recorded using three validated shoulder scoring systems. The first assessment given was the Western Ontario Shoulder Index (WOSI) as described by Kirkley et al and was administered at the latest follow-up[20]. The WOSI has gained acceptance as a useful assessment tool to grade shoulder instability[21].The patients were evaluated in 4 categories, including physical symptoms, sports, recreation, lifestyle, and emotions. Each question was graded from 0-10 with 0 being perfect function and 10 being the worst possible outcome. These categories produced a total of 21 questions with the final score expressed as a percentage; hence 100 would be a perfect WOSI score.

The other assessments were the American Shoulder and Elbow Surgeons (ASES) and PENN shoulder scores, also recognized as validated assessment tools[22, 23]. The ASES and PENN scores were similarly measured at the latest follow-up. The areas of assessment included pain, satisfaction, and function for the PENN shoulder score (0-100 point scale). The ASES shoulder score addressed pain and function (0-100 point scale). Averages of both scores were calculated out of potential 100 points for the study population[24].

A 0-10 point scale determined the patient's shoulder pain score; with 0 being no pain and 10 unbearable pain for both the PENN and ASES shoulder scores. There were four separate pain scores: pain today, pain at rest, pain with daily activities, and pain with strenuous activities. The final score was the average of the scores for each of the 4 categories of pain.

Satisfaction was determined by a 0-10 point scale, and was based on the guidelines of the PENN shoulder score.The score of zero was totally unsatisfied and ten was very satisfied, with the questionnaire posing only one question for assessment. The average of all patients was calculated for results tabulation. Statistical analysis between the groups with different humeral pathology was performed using Mann-Whitney U test.

The Surgical Technique

The patient is positioned in the lateral decubitus position and leaned back slightly with the shoulder in 45 degrees of abduction and 15 degrees of forward flexion. The arm is then suspended with appropriate weight to give adequate traction. The posterior portal is established slightly lateral to the convexity of the humeral head to visualize the Hill-Sachs lesion. The anterior-inferior portal is established within the rotator interval, and the anterior-superior portal is established at the anterior margin of the acromion, superior and just posterior to the biceps tendon. The anterior-superior portal is used for visualization of the humeral defect, and to assess the placement of the posterior portal. The posterior portal should be directly over the humeral head defect for the purpose of anchor placement. Once appropriate posterior portal placement is confirmed, the Hill-Sachs lesion is gently debrided with a shaver or thermal device. For the purpose of the Bankart repair, the anterior labrum and glenoid need to be prepared at this time, prior to the Remplissage procedure (infraspinatus tenodesis). After adequate preparation for Bankart repair, the posterior portal is used to deliver an anchor into the defect (Figure 1). The cannula is withdrawn external to the infraspinatus and a penetrating grasper is passed through the tendon and posterior capsule both proximal and distal to the initial portal entry site, to grasp and pull 1 suture limb. A second anchor is placed in the superior aspect of the humeral head defect, if necessary, and a grasper penetrator is used in the same fashion to pass 1 suture limb both proximal and distal to the initial portal entry site. The inferior suture is tied first with the knots remaining extra-articular in the sub-

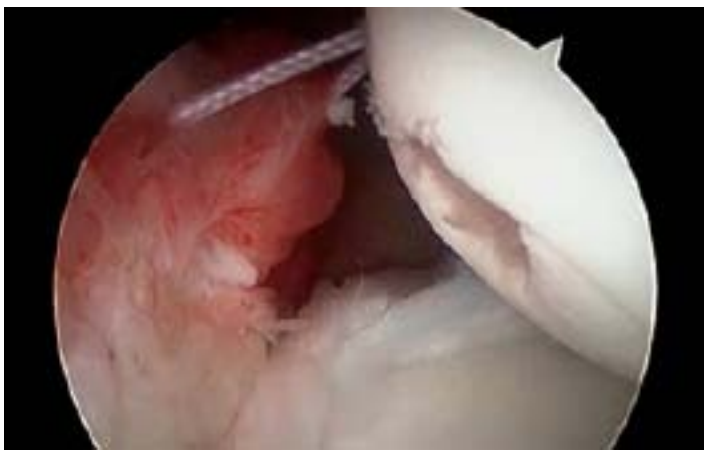

Figure 1. Anchors placed in the humeral head in preparation for Remplissage.

Figure 2. Infraspinatus is tenodesed into the humeral head defect.

deltoid space. The superior set of sutures is tied to complete the Remplissage (Figure 2). These mattress sutures draw the infraspinatus and posterior capsule to the prepared bony surfaces, thus filling the Hill-Sachs lesion. The Bankart repair can then be completed in a usual fashion.

Postoperatively, patients are immobilized in a sling for 5 weeks, with gentle activities of daily living allowed out of the sling. Gentle active and active assistive ROM is allowed at 6 weeks post-operatively. Patients are instructed not to abduct or externally rotate the arm beyond neutral until 6 weeks. At three months, progressive capsular stretching and strengthening of the shoulder are allowed. Patients are allowed to resume their pre-injury level of activity at 6 months post-operatively or when shoulder strength is 90% of the unaffected limb.

Results

We defined the size of the lesion according to the criteria defined by Rowe et. al[10]. Nineteen out of the 20 patients had a moderate to severe humeral defect (larger than 2cm long/0.3cm deep). All humeral defects were greater than 25% of the humeral head circumference. The dominant arm was involved in 9 out of 20 (45%) patients. The average surgery duration was approximately 2 hours. There were 15 males and 5 females in the study population with an overall average age of 27.3 years and an average follow up of 24.6 months (range 18.2 to 32.7 months). There were 5 patients with shoulder pathology in addition to Hill-Sachs lesion and Bankart lesion with the average age of 36.2 years (20-75 years), and 15 patients without the concomitant shoulder pathology had average age of 24.2 years (range 17-36 years, Table I). The concomitant lesions included ALPSA lesion (n = 2), Kim lesion (n = 1), SLAP lesion (n = 1), and one patient with a partial articular sided tendon lesion (PASTA) lesion (5%). All of the concomitant pathologies were addressed (debridement v. repair) during the procedure. Average total PENN shoulder score was 90.0. The average PENN functional score was 54.3, average PENN pain score was 27.3 and the average PENN satisfaction score was 8.5. For patients with concomitant lesions, the average total PENN score was 88.2 (functional score average: 51.20, pain score average: 28.2, satisfaction score average 8.8). There was no statistical difference in PENN shoulder scores for patients with concomitant pathology compared to the rest of the study population ($p = 0.93$, Table II).

The average total ASES shoulder score was 92.5. The average ASES functional score was 45.3 and the average ASES pain score was 47.3. For patients with concomitant lesions, the average total ASES score was 88.7 (functional score average: 42.67, pain score average: 46.00). There was no statistical difference in ASES shoulder scores for patients with concomitant pathology compared to the rest of the study population. ($p = 1.0$, Table 2).

The average total WOSI score was 572.50 calculated for an average percent of 72.74 % with 100% being perfect. The average for the WOSI physical symptom score average was 77.10%, sports and recreation average was 70.25%, lifestyle score average was 75.00%, and emotions score average was 58.50% (corresponding raw scores: physical symptoms score 229.00, sports and recreation score of 119.00, the lifestyle score 100.00, emotions score was 124.5). For patients with

Table I. Demographic Data

Parameters	Hills-Sachs/ Bankart only	Additional Pathology
Number	15	5
Age (yrs)	24.2 (17-36)	36.2 (20-75)
Follow-up (months)	24.0 (18.2-30.4)	26.2 (21.3-32.7)
Male	12	3
Female	3	2
Dominant Arm	8	2
Dislocations Post-OP	1	2
Dislocations Pre-OP		
1	1	0
2 or 3	7	2
4+	7	3
Prior Shoulder Surgery	1	1

Table II. Outcome Scores

Parameters	Additional Lesion	No.	Mean	p-value
PENN Total	None	15	90.6	0.93
	Additional Lesions	5	88.2	
	ALPSA	2	98.0	
	Kim	1	85.0	
	SLAP	1	100.0	
	PASTA	1	60.0	
ASES Total	None	15	93.8	1.0
	Additional Lesions	5	88.7	
	ALPSA	2	98.8	
	Kim	1	89.2	
	SLAP	1	100.0	
	PASTA	1	56.7	
WOSI Final (%)	None	15	74.6	0.93
	Additional Lesions	5	68.2	
	ALPSA	2	90.5	
	Kim	1	32.9	
	SLAP	1	92.9	
	PASTA	1	29.5	

concomitant lesions, the average total WOSI score was 67.2% (physical symptom score average: 46.00%, sports and recreation average: 68.00%, lifestyle score average: 72.40%, emotions score average: 76.00%). There was no statistical difference in WOSI scores for patients with the concomitant pathologies compared to the rest of the study population ($p = 0.93$, Table II).

Three patients experienced recurrent instability (15%) in the study population. The episodes were atraumatic in nature, and spontaneously reduced per history. None of the three patients elected to pursue further surgical intervention. None of the patients experienced surgical site infection, and there were no complications associated with the suture anchors.

Discussion

Hill-Sachs lesions were not fully appreciated pathologically until Burkhart & DeBeers' work in 2000. They observed 194 patients, 3 of whom had large, engaging Hill-Sachs lesion and all 3 experienced recurrence of shoulder instability[7]. Increasingly, investigators have attributed recurrent instability to the presence of Hill-Sachs lesions[25]. In a study by Lynch, the authors attributed up to 93% of cases of recurrent instability to large engaging Hill-Sachs lesions[8]. Patel et al attributed most failures of prior instability surgeries to unidentified Hill-Sachs lesions[4]. In general, most of the primary failures were associated with a Bankart repair. This is understandable since Widjaja et al found an 80% correlation between Bankart lesions and humeral head defects[1]. In our study, all of the patients with humeral head defects identified by intra- operative assessment had confirmed Bankart lesions as well.

The Remplissage technique is unique as the surgeon is already in position for arthroscopic visualization and can address both the humeral head defect and the Bankart lesion during the same operation. As a result, both repairs can be done quickly and efficiently, potentially saving the patient from more extensive (open) surgery and prolonged anesthesia. There are few published reports on the Remplissage technique, without comprehensive outcomes measures having been reported. The first report by Connolly et al described a transfer of the infraspinatus by an open technique. Fourteen of fifteen patients had good results with no apparent complications.[16] Purchase et al described their own dislocation rate at 2 out of 24 patients, with no significant complications or loss of range of motion[17]. We have verified these results in the present study in which we had a recurrence rate of 15% with an average of 24 months of follow-up.

Data is still unclear on the best approach to manage the humeral head bony defect. The "gold standard" procedure at this time for the repair of glenohumeral defects remains the Latarjet procedure first described in 1954[26]. It involves coracoid transfer to the glenoid rim, improving stability by increasing the articular arc length in patients with Hill-Sachs pathology[27]. The recurrence rates for this procedure range from 0-12%[13, 14, 28]. The results of these studies are comparable to our recurrence rate of 15%. The main question is whether the Latarjet procedure will prevent engagement with lesions that are large and have a small articular arc length since the procedure does not directly address the lesion. Also, it is difficult to know whether the benefits of the procedure outweigh its complications. Allain et al reviewed 56 patients (58 shoulders) over 14.3 years of follow-up, which showed a 90% recurrence of instability and over 50% of cases with too lateral coracoid placement, which subsequently led to glenohumeral arthritis[13]. Furthermore, increasing evidence is mounting that subscapularis violation may lead to persistent atrophy[29]. While the long-term results of Remplissage are not available, the high prevalence of surgical complications and co-

morbidities of the Latarjet procedure makes the Remplissage procedure a potentially more attractive alternative.

One can also utilize the iliac crest bone grafting technique to address bone defects about the shoulder. Iliac crest bone grafting offers an alternative to a Latarjet coracoid transfer by implanting autograft iliac crest onto the anterior glenoid, increasing the articular arc length and preventing engagement of the humeral head on the anterior glenoid. The results of Warner et al included 11 patients with no recurrent instability but only 5 of which had large Hill-Sachs lesions with no mention of engagement pre-operatively[11].

Another well accepted procedure for the repair of large Hill-Sachs lesions is an osteochondral allograft transplantation. This procedure involves placing an osteochondral allograft in the humeral head defect, therefore filling the defect and eliminating the possibility of the humeral head engagement on the anterior glenoid[15,30,31,32]. Most of the studies published have been single case reports, however Miniaci et al reported results of 18 patients with large humeral head defects with no recurrent instability after 2 years of follow-up[33]. Even with good results, there were several complications including graft resorption, non-union and hardware failure, confirmed by Miniaci with 2 of 18 patients (11.1%) requiring screw removal[8,33]. Furthermore, graft procurement, disease transmission and cost remain considerations. From our experience, the Osteoarticular Auto/allograft Transport System (OATS) procedure seems to be the most comparable to Remplissage in terms of addressing the Hill-Sachs lesion arthroscopically.

Another procedure for addressing humeral head defects is the transhumeral head plasty.This involves an anterior cruciate ligament tibial guide and a bone tamp with allograft bone chips which are used to fill the lesion of the humeral head[34]. Re et al. performed the procedure on 4 patients with no recurrent instability after 12 months[34]. Despite these results, questions still remain due to the small patient population assessed and the possibility of the tamp procedure's limited effectiveness for large and more chronic defects[8]. The humeral head osteotomy technique can be utilized to address the humeral head defect as well. It involves rotation of the humeral head to create retroversion of the humerus, therefore preventing engagement of the Hill-Sachs lesion. Weber et al reported no recurrent instability or glenohumeral arthritis in 20 patients[35]. Even with these good results there is still potential for complications which may involve hardware failure, and decreased internal rotation. Prior studies on this procedure also showed that approximately 60% of the patients had to have a second operation for hardware removal[7, 27].

Previously, there were a few studies with comprehensive outcome measures for shoulder stabilization.Tjoumakaris et al reported similar ASES scores for the patient who underwent either isolated open or arthroscopic Bankart repair (90 vs. 89.1), and Patel et al reported an average ASES score of 81.1 and WOSI score of 68.2 in their cohort of patients who underwent revision shoulder arthroscopy for recurrent instability[2,4]. Our study population had comparable scores with more complicated pathology, with an average ASES score of 92.5 and an average WOSI score of 72.74.

The Remplissage technique showed promising results with 19 of 20 patients with good outcomes. The recurrence rate of 15% is comparable with other more extensive procedures that address the humeral head defect [2, 6, 8, 28, 33, 34, 36]. Our ASES and PENN shoulder scores were 92.5 and 90.0 respectively, which showed acceptable overall patient satisfaction, limited pain and good shoulder function. Our WOSI score of 72.74 demonstrates that most of our patients have developed good stability and returned to their original sport or hobby. The emotions section of the WOSI scores showed significantly lower average compared to the other sections with an average percentage score of 58.50. This result is likely attributed to patients' prior experience of recurrent dislocations and we would anticipate improvement in this parameter over time.

Three patients in the current study experienced recurrent instability. One of the three patients with the post-operative instability reported significantly lower scores compared to the others (ASES = 56.7, PENN score = 60.00, and WOSI score = 29.52). This patient had a concomitant PASTA lesion identified intra-operatively, which was repaired. The patient elected not to pursue any further surgical intervention. The limitation in range of motion that can accompany concomitant rotator cuff repair in this population may have attributed to this poor outcome.

Our study has several limitations. The investigation did not fully test for external rotation. Deutsch et al reported a case report on a patient having significant loss of external rotation following the Remplissage procedure[18]. There is a potential with the Remplissage technique to cause a disabling lack of external rotation. This could ultimately require infraspinatus release to correct. However, we did not encounter such complications in our series, and the external rotation deficit was not reported on the other available studies[17,19].The majority of patients in our series achieved excellent scores on the PENN and ASES functional scales, which evaluate shoulder external rotation with several activities such as combing hair overhead, placing hand behind head with elbow straight out to side, overhead racquet sports, overhead throwing, and swimming. We also showed that on the WOSI question on range of motion, patients reported the average percentage score of 73.0, which demonstrates subjectively good shoulder mobility. From the previous reports that evaluated the patients who underwent shoulder instability surgeries, the loss of external rotation can ranged from 13°-21°[8,11,13]. We have no reason to suspect that our patient population experienced a worse outcome. In general, external rotation is not recommended following procedures addressing shoulder instability, and our successful results in addressing the pathology may be associated with post-operative restriction of motion rather than the filling of the defect[7, 27]. Dynamic MRI imaging may be helpful in the future in answering this question.

Another limitation of our study is the lack of pre-operative functional assessment. This study is retrospective in design, and so selection bias may be evident. The senior author transitioned his practice to an all arthroscopic approach before the study period, and no patients received other humeral head or glenoid grafting procedures to address

instability during this period. The lack of pre-operative data prevents us from assessing post-operative improvement objective measures. However, we believe that in every case, patients were functionally disabled with routine episodes of shoulder instability with activities of daily living. With 24 months of average follow up, one may argue that the patients are not followed long enough to fully assess the long term outcome. Because the Remplissage technique was only recently introduced, longer term follow up will not be available for a few years. If long-term complications are found, we can expect them to be comparable in severity to the other glenohumeral defect surgeries discussed previously which are already considered "gold standards".

A lesion as small as 12.5% defect in humeral head can be a significant source of shoulder instability[37]. The Remplissage technique achieves good results for patients with anterior shoulder instability associated with significant, engaging humeral head defects with concomitant Bankart lesions at short term follow-up. It is a less demanding procedure than allograft and coracoid transfer with the added benefit of lower morbidity and it can be performed arthroscopically at the same time as a Bankart capsulorrhaphy. Further studies will be necessary to see if the good results seen in the current study can be maintained at longer follow-up.

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